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CHEMISTRY.—*The evolution of matter.*[1] FRANK WIGGLESWORTH CLARKE, U. S. Geological Survey.

During the greater part of the nineteenth century many philosophical chemists held a vague belief that the so-called chemical elements were not distinct entities, but manifestations of one primal form of matter, the *protyle*, as it was sometimes termed. Other chemists, more conservative, looked askance at all such speculations, and held fast to what they regarded as established facts. To them an element was something distinct from all other kinds of matter, a substance which could neither be decomposed nor transmuted into anything else. One fact, however, they ignored, namely, that the elements were intimately connected by many relations, which are best shown in the periodic law of Mendeléeff, who actually predicted the existence of unknown elements which were afterwards discovered. This is ancient history, with which all chemists are now familiar. It became evident to most chemists that the elements must have had some community of origin, for otherwise their relations to one another are unintelligible.

In 1873 I ventured to publish the suggestion,[2] based on spectroscopic evidence and assuming the nebular hypothesis to be true, that the evolution of planets from nebulae had been accompanied by an evolution of the chemical elements. The nebulae are chemically simple, the hotter stars more complex, the cooler stars and the Sun still more so, and the solid Earth the most complicated of all. This was promptly denounced as heresy; but nearly a year later Lockyer[3] put forth an analogous suggestion, based upon the same sort of evidence, but starting from the other end. That is, he assumed that in the hotter stars some elements were dissociated, and his suggestion was received with a good deal of favor. The heresy was beginning to be orthodox. In course of time the discovery of radioactivity by Becquerel and of radium by Madame Curie established the fact that

[1] Published with the permission of the Director, U. S. Geological Survey. Received June 16, 1921.

[2] F. W. CLARKE, *Evolution and the spectroscope*. Pop. Sci. Mon. January, 1873.

[3] N. LOCKYER, Proc. Roy. Soc. 21: 513. (Paper dated Nov. 20, 1873).

some, at least, of the elements were really unstable. The evolution of helium from radium, discovered by Ramsay and Soddy, made the evidence for this instability complete; a derivation of one element from another had actually been observed.

These discoveries opened a new field of research; and it was soon found that the elements at the top of the atomic weight scale, namely, uranium and thorium, are spontaneously but slowly decaying, yielding more than thirty new substances which differ widely in point of stability. To each one a half-life period is assigned, measured in some cases by thousands of years, in others by fractions of a second. Among these are two new varieties of lead; one derived from uranium, the other from thorium, which chemically are not distinguishable from ordinary or normal lead except by differences in their atomic weights and their specific gravities. The lead from thorium has an atomic weight about a unit higher, and that from uranium about a unit lower, than the atomic weight of normal lead. To this class of facts I shall refer later, as evidence in support of my arguments. That chemical elements can decay is the essential fact to be remembered.

That the chemical elements were formed by a process of evolution from the simplest forms of matter can hardly be doubted now, but the process is not yet ended. They were developed at high temperatures; but when a certain stage was reached in the cooling mass they began to combine with one another to form the new class of substances which are known as compounds. These, obviously, represent an advanced degree of complexity, with corresponding instability; and with varying conditions both combinations and decompositions, such as are reproducible by human agencies, constantly occur. By this extension of the evolutionary process the solid Earth was built up, but in principle the process is the same throughout. From the formation of the first elements to the chemical changes now taking place upon the Earth there is no real interruption. One line of progress has been followed until a maximum of natural complexity and instability is reached in the organic compounds which form the basis of all physical life, whether vegetable or animal. The same fundamental matter, governed by the same fundamental laws, appears from beginning to end of the evolutionary process.

Between the formation of an element and the formation of a compound there is, however, an apparent difference. The first stage of the process was one which required a vast period of time, the second stage is marked by rapidity. The series of elements was slowly

formed, and their rate of decay, as shown between uranium and lead, is also relatively slow. The formation and decomposition of compounds, on the other hand, is rapid; and in some cases their rate is measurable. The distinction is not absolutely definite, for some of the short-lived products of radioactive decay seem to be exceptions to the rule, which in general may be stated as follows: The process of evolution is characterized by progressive acceleration, being slow at first, and becoming gradually more and more rapid. Its rate of acceleration may not be uniform but the general drift is clear. It follows the line from the simplest substances to the most complex. In all vital processes the ease and rapidity with which compounds are formed and developed is evident, and some of these substances are extremely complicated.

In any attempt to discuss the evolution of the chemical elements we have for guidance some facts and many analogies. That the most complex elements are unstable we have already seen, and it is suspected that all the others follow the same rule. Potassium and rubidium are feebly radioactive, which is an evidence of instability, and other confirmatory evidence will be cited later. Stability, however, is a relative term, and a substance which is stable under certain conditions becomes unstable under others. The prime factors which determine external stability are temperature, pressure, and chemical environment. For example, some compounds which are stable in anhydrous surroundings are decomposed in presence of water. Calcium carbonate, under ordinary conditions, is divided at high temperatures into carbon dioxide and lime, but heated in a steel bomb it not only remains undecomposed, but it may even be melted, to form upon cooling a crystalline marble. Examples like these might be multiplied indefinitely. As a rule stability diminishes with increasing temperature, but is favored by increased pressure. We may also assume that the more symmetrical an atom or compound is, the more stable it is likely to be. We are dealing now with compounds; but to the evolution of the elements the same general rules must apply.

Now, returning to our main problem, was the evolution of the elements a regular progression, such as might be represented by a smooth curve or a straight line; or was it irregular and quite independent of their order in the scale of atomic weights? To answer this question we must try to imagine what happened in the development of the larger masses, the nebulae and the stars. On this subject there is a plausible hypothesis which has been favored by many astronomers;

namely that the nebula at first was relatively cool, that the temperature gradually rose to that of the hottest stars, and then regularly declined to the end of the series, the solid planet. A gaseous mass, contracting under the influence of gravitation, became warmer; at its center where the pressure was greatest, the increasing condensation generated still higher degrees of temperature, until a luminous nucleus was formed. As condensation went on with increasing intensities of pressure, the temperature continued to rise until the heat generated by compression was less than that lost by radiation into space, when cooling began. Although this hypothesis, in its crude form, is not universally accepted, it nevertheless gives a fair conception of that part of the evidence with which we are now concerned. The process of evolution from cool to hot and then to cool again is fairly outlined. The nucleus of the original nebula has its modern representative in the Sun.

In all the foregoing discussion it has been tacitly assumed that the nebula from which the solar system was developed was similar in all essential respects to the planetary nebulae. The latter, as shown by their spectra, consist mainly of hydrogen, helium, and nebulium, with slight traces in some of them of carbon, nitrogen, and perhaps other elements. Nebulium is known only from its lines in the spectrum, and its atomic weight has been estimated by Fabry and Buisson as 2.7, placing it between hydrogen and helium. In any further study of relations between the atomic weights of the elements, nebulium must be taken into account, and perhaps also coronium, so called from its lines in the spectrum of the solar corona. From its position in the corona it is assumed to be lighter than hydrogen, and so would seem to be an even more primitive element. That possibility cannot be considered here; we must limit ourselves to the conditions actually seen in the nebulae. No assumption is made as to the possible ancestry of the nebular elements. They are the visible beginnings.

Now it is easy to see that in the process of evolution from nebula to sun an orderly development of the elements could hardly have been possible. With changing temperatures, changing pressures, and changing environments all the conditions required for a regular progression according to the order of the atomic weights were lacking. The order actually followed was that of relative stability. In the hotter stars only the most stable elements were formed, and naturally in the greatest abundance. Calcium (atomic weight 40) and iron (atomic weight 56) were among the earliest to appear, while the others,

between helium (atomic weight 4) and iron, either came later or were developed at first in smaller quantities. As cooling went on more and more elements were generated, and in the Sun all the possible ones are presumably present. It is conceivable that elements of different stability may have been formed simultaneously, one in that part of the cooling mass where temperatures and pressures were highest, another further away from the center under less rigorous conditions. This, however, is something which cannot be proved. If the three nebular elements were the raw material from which the other elements were built, their relative amounts must have been continually changing, and so as each new element appeared a new environment was established for all that followed. How far these changes may have affected the evolution of the elements it is impossible to say, but in the evolution of compounds similar conditions would be significant.

That some of the chemical elements are very abundant, and others comparatively scarce, is a familiar fact which bears directly upon the theory of evolution. Their relative abundance in known terrestrial matter has been repeatedly computed, by several workers and by different methods. The results agree remarkably well, at least in the orders of magnitude as expressed in percentages. This order, when we combine the figures for the lithosphere, the ocean, and the atmosphere, is as follows. First, oxygen, then silicon, aluminum, iron, calcium, sodium, potassium, hydrogen, and titanium, and these ten elements form at least 98 per cent of the whole. Only 2 per cent remains for all the other elements, some 80 or more in number.[4]

For present purposes this estimate is obviously defective, for it covers hardly more than a thin film on the surface of the Earth and says nothing about the Earth's interior. This objection is easily met if we take three facts into consideration. The Earth behaves like a huge magnet, it resembles a huge meteorite, and its mean density is double that of the rocks forming its crust. From these facts, and other quite minor considerations which need not be discussed here, we may fairly assume that the interior of the Earth contains a large proportion of metallic iron, and the quantity of it needed to give with the crust the mean density of the globe can be calculated. This has been done by others, and it now appears that in the Earth as a whole, iron predominates, oxygen and hydrogen fall to subordinate positions while the order of the other elements is little changed. Probably

[4] The details of the most recent computation of the relative abundance of the elements will appear in a joint paper by Dr. H. S. WASHINGTON and myself, which is in course of preparation.

nickel would appear among the first ten elements, but such a change will not affect our argument. Ten or eleven elements, all below 59 in atomic weight, exceed in abundance all the others. They are structurally among the simplest elements, and therefore, presumably the most stable.

These conclusions may now be applied to the hypothesis of evolution. The total amount of matter in the original nebula was of course finite; a large part of it was absorbed in building the simpler and more stable elements, and only what remained was available for the development of all the others. This conclusion, I admit, is largely speculative, but it is a legitimate interpretation of evidence. It may be modified by future investigations, but it is not likely to be completely overthrown. It is possible that the relative abundance of the elements may be different in different parts of the solar system, but it is not probable that any of the higher elements can find a place among the first ten. The whole scheme of evolution may be figured diagrammatically as a series of waves in which the crests represent the elements, and the depressions the gaps between them. In such a series the waves would reach their greatest height at iron, and then gradually flatten until the end where instability becomes most clearly evident.

Between the evolution of the elements and their degradation there is a sharp contrast. The two processes do not follow the same path. Uranium does not decay to thorium, that to radium, then to lead, and so on down the line. The same divergence is shown between the synthesis and decomposition of compounds. It would be easy, for example, to effect a direct synthesis of calcium carbonate from its elements; but to reverse the process without the intervention of other substances would be extremely difficult. To cite a different example, trinitrotoluene, the T.N.T. of recent warfare, is prepared by the action of nitric acid on toluene, a relatively slow operation. On the other hand, when T.N.T. decomposes it does so instantaneously, and the products are oxides of carbon, methane, water, and free nitrogen. Something like this happens in the decay of a radioactive element, but with a difference; uranium, thorium or radium decomposes atom by atom; T.N.T. flies to pieces in mass. The one process is slow, the other extremely rapid.

I have already specified the external conditions which determine the stability of an element or compound, but when we consider the atom by itself, internal conditions are more important. On the

structure of atoms there is not as yet a complete agreement, and much remains to be done before the problem can be definitely solved. I cannot go into this subject in detail, but I may take it for granted that the conception of an atom as consisting of an electropositive nucleus attended by few or many electrons of opposite sign, is well established. In such a structure symmetry would be conducive to stability, and any deficiency in that respect would be unfavorable. For a simple element, with few electrons, symmetry would be most easily attained, for a complex element with many electrons it would be more difficult. Furthermore, an atom to be stable must show an exact balance between the electropositive and electronegative charges. With a single ring or shell of electrons the force of attraction holding nucleus and electrons together should be strongest; with concentric rings of electrons the outer ones would be more loosely held, and the atomic structure should be weaker. This seems to be the case with uranium and its neighbors. Here the structures are the most complex, and the number of electrons greatest. In short, the conditions, internal and external, which determine stability are by no means simple, and some of them operate in opposite directions. They all agree, however, in favoring the evolution of the simpler elements and so render the fact of their greater abundance more intelligible.

When an atom of uranium decays, an *alpha* particle, which is an atom of helium, is first discharged, and with a very high velocity. By a succession of such discharges a series of products is generated, each one differing by four units in atomic weight from its predecessor. The atomic weight of helium is 4. Three of these products, omitting intermediate forms, are ionium, radium, and an "isotope" of lead. Ionium is isotopic with thorium, but not identical with it except in its purely chemical relations. The atomic weights are not the same. A similar difference is found for the lead derived from radium, which differs from normal lead in having an atomic weight about a unit lower. The isotope of lead in the thorium series differs from the normal by about the same amount in the opposite direction.[5] In short, the degradation path from uranium, and also that from thorium is approximately parallel to the path of evolution, but not identical with it. The short-lived products of radioactive decay might be described as the debris of exploding atoms. They do not appear in the ascending series of the elements.

[5] For a discussion of the nature of isotopic lead see CLARKE, Proc. Nat. Acad. Sci. 4 181. 1918.

For the elements below the radioactive group, that is, those of lower atomic weight, some evidence of instability has recently been obtained. Rutherford, by passing swiftly moving *alpha* rays through nitrogen, has observed a slight evolution of hydrogen, an indication that hydrogen is a constituent of the heavier and more complex element. Oxygen, treated in the same way, yields a product of different character, something which appears to have an atomic weight near 3. If, however, the value should be slightly lower, it would have a curious significance. Attention has already been called to the existence of nebulium, to which the atomic weight 2.7 has been provisionally assigned. This is very close to 2.666..., or $2\ ^2/_3$ more precisely.

Now $2\ ^2/_3 \times 6 = 16$, the atomic weight of oxygen, a relation which may possibly be experimentally verified. If the bombardment of oxygen were carried on for a long time it might yield a gas in which the spectral lines of nebulium could be detected; and if that were done it would be a step forward in the study of the atoms. I offer this suggestion with some hesitation, but it seems to be worth considering. It affects a number of other elements of which the atomic weights are multiples of 16.

By a remarkable series of experiments F. W. Aston[6] has obtained evidence which he regards as proof of the complexity of the atomic weights as determined by chemical methods. Powerful positive rays in a magnetic field were applied to a number of elements, which then gave what he terms their "mass spectra." These spectra show lines corresponding to whole number atomic weights, which represent, not the accepted values, but some higher and some lower. Chlorine gives two such lines, corresponding to atomic weights 35 and 37, and mercury gives at least six, ranging from 197 to 204. The last two figures, I may add, are near the atomic weights of gold and thallium, that of mercury being 200.6. These new lines, as interpreted by Aston, represent isotopes, and the accepted atomic weights are regarded as mere statistical averages. In other words the atomic weights known to chemistry relate to mixtures, and are not true constants.

I must here allow myself to indulge in a very obvious truism. Whenever new phenomena are discovered an attempt is made to interpret them, and to bring them into relations with other phenomena.

[6] Science Progress 15: 212. 1920.

But it does not always follow that the first interpretation is the only one possible, nor even that it is the best. Now it seems to me conceivable, that the lines of Aston's mass spectra may really belong to decomposition products of the elements, produced by the disintegrating effect of the positive rays. This conclusion, I think, is more in harmony with chemical evidence than the one first proposed. It is, furthermore, sustained by the fact that the elements of high atomic weight seem to show as a rule more lines in their mass spectra than those low in the scale. The most complex elements should undergo the largest amount of disintegration. If the atomic weights as actually determined by the best modern methods are mere statistical averages of widely differing figures, then the elements must be regarded as variable mixtures, and uniformity could hardly be expected. This lack of uniformity would extend to all chemical compounds, which should vary in composition and also in physical properties; all chemical calculations would become inexact, and even the spectra of the elements would lose much of their significance. Chaos would rule instead of order.

In point of fact the evidence in favor of definiteness of atomic weight is much better than anything which has been adduced to the contrary. On that subject I could make a strong argument in support of my position; but I do not care to overload this paper with details. In discussing the evolution of the elements, and also their decay, I must take a pragmatic position and assume their integrity. Their evolution follows an upward path, with which the downward path of decomposition is approximately but not exactly parallel. The two paths, however, coalesce in the region of hydrogen, nebulium, and helium; and so the beginning and the end are the same. That hydrogen and helium are the chief constituents of the elements as we know them is possible, as Harkins in a long series of interesting papers has attempted to show. I cannot accept all his conclusions as final, although he has at least discovered some interesting relations. Nebulium should not be left out of account.

On the mechanism of the process by which the elements were built up I have nothing definite to say. I can only ask questions. If a heavy atom, like that of gold or mercury, is formed from simpler atoms, how are the latter changed? What happens to their nuclei and their electrons? Is the structure of the carbon atom the same in graphite and in diamond? Here the tetrahedral atom which plays so important a part in stereochemistry has to be considered.

With compounds these problems become much more complicated, that is, if we try to explain them in terms of atomic structure. Among organic compounds we find isomers and polymers, and many of them contain a hundred or more atoms to the molecule. How are their electrons rearranged, and what are they doing? All of these compounds, as I have already shown, are items in the general scheme of the evolution of matter, in which the question of atomic structure is fundamental. I have in this paper only touched the surface of a vast general problem, but my imagination has never wandered far from evidence and reasonable analogies. Perhaps I have made suggestions which may lead others to the discovery of new truths.

MINERALOGY.—*On galenobismutite from a gold-quartz vein in Boise County, Idaho.*[1] EARL V. SHANNON, Department of Geology, United States. National Museum. (Communicated by E. T. Wherry).

The mineral galenobismutite, first described by Sjögren from the Ko Mine, Nordmark, Sweden[2] has not heretofore been definitely identified at any second locality. The material from Fahlun, Sweden, described by Atterberg[3] contains more selenium than sulfur and is doubtless either a mixture or a variety of weibullite or platynite. It is listed as a distinct species by Hintze[4] under the name "selenbleiwismuthglanz."[4] Alaskaite, included by Dana under galenobismutite, is regarded by Hintze and also by Wherry and Foshag as a distinct species.[5] The lead sulfo-bismuthite from the tungsten veins of Deer Park, Washington, analyzed by R. C. Wells and described by Bancroft[6] as intermediate between galenobismutite and cosalite is quite probably distinct from either. It thus appears that galenobismutite, properly so-called, is an exceedingly rare mineral. For this reason it becomes of interest to note that this mineral occurs as a constituent of a gold ore from Idaho preserved in the United States National Museum.

[1]Published by permission of the Secretary of the Smithsonian Institution. Received May 25, 1921.

[2] H. SJÖGREN. Geol. Foren. Forh. 4: 109. 1878.

[3] ATTERBERG. Geol. Foren. Forh. 2: 76. 1874.

[4] C. HINTZE. *Handbuch der Mineralogie*, 1: 1012.

[5] E. T. WHERRY and W. F. FOSHAG. *A new classification of the sulfo-salt minerals.* This JOURNAL 11: 1–8. 1921.

[6] HOWLAND BANCROFT. *Notes on tungsten deposits near Deer Park, Washington.* U. S. Geol. Survey Bull. 430: 216. 1910.

The specimen was collected by Edward L. Jones, Jr., of the U. S. Geological Survey and is included in an unstudied collection of ores from southern Idaho. The label gives as the field number SI-106, and as the locality, Belzazzar Mine dump, Quartzburg district. The specimen was collected September 15, 1915. Regarding the Belzazzar Mine, Lindgren states that it is located on the Fall Creek side and has been opened by sluicing and a tunnel, 200 feet below the summit. Bodies of heavy sulfurets, chiefly pyrite, are exposed along the vein. The western part of the vein lies in hornblende porphyrite, while the eastern end has granite in the footwall and the same porphyrite in the hanging wall.[7] Bell gives the location of the mine as near the Jerusalem Valley road, a little west of Quartzburg.[8] He states that the ore is merely an altered phase of the enclosing rock traversed by quartz seams. The ore was free-milling on the first and second levels and produced fine specimens of free gold. The third level, however, showed considerable amounts of sulfides and only half of the gold in this sulfide ore was recoverable by amalgamation. The ore is said to average from $8.00 to $12.00 per ton.

The specimen which contains the galenobismutite consists in the main of translucent to transparent crystalline white vein quartz. The sequence of deposition of the minerals is not entirely clear but there is a band of more or less pure pyrite adjacent to the wall of the vein and this pyrite appears to be the earliest mineral of the ore. The quartz is slightly sheeted parallel to the vein wall, small grains of pyrite being distributed along the partings. Pyrite occurs also in crystalline grains through the quartz and also as sharply bounded cubic crystals in greatly sericitized fragments of wall rock which occur in the quartz. The quartz is loose textured and contains small angular cavities between the crystals. The galenobismutite occurs interstitially with relation to the quartz crystals and projects as fibrous bundles of prismatic needles into the cavities. It is clearly the youngest mineral of the vein, the common paragenetic position of the majority of the lead sulfo-salts.

The galenobismutite is rather light gray in color and tarnishes to a yellowish color. Its luster is rather more brilliant than that of the antimonial sulfo-salts of lead, and the mineral greatly resembles bismuthinite in general appearance. It forms elongated prisms im-

[7] WALDEMAR LINDGREN. *Mining Districts of the Idaho Basin and Boise Ridge, Idaho.* U. S. Geol. Survey, Ann. Rept. 18, Pt. III: 690. 1896–97.

[8] ROBERT N. BELL. Rept. Idaho State Inspector of Mines for 1905, p. 33.

bedded in quartz or minute, deeply striated crystals in open cavities. The streak is black on porcelain or brownish black when rubbed very thin with a glass rod. The hardness is about 2.5.

Material for analysis was secured free from impurities other than quartz and a little pyrite, both of which remained unattacked when the mineral was dissolved in hydrochloric acid. The material was found to be free from other impurities by examination of polished surfaces under the miscroscope. Standard methods of analysis were used, the bismuth and lead being separated by the basic nitrate method. It is noteworthy, however, that this method, which is the one recommended by most textbooks, is one which gives satisfactory results only when performed with extreme care. The major separation was accomplished by precipitating the bismuth by means of hydrogen sulfide in strongly acid solution, the precipitate being almost free from lead while very little bismuth remained in solution. The separation by the basic nitrate method was repeated several times on each product of this separation before these two metals were obtained free from each other. The material available for analysis was too small to permit sulfur to be determined. The results of the analysis, recalculated after deducting gangue, are given in table 1.

TABLE 1.

ANALYSIS OF GALENOBISMUTITE FROM IDAHO

		Per cent	Calculation of Ratios		
Lead	Pb	23.93	0.1155		
Iron	Fe	.39	0.0057	1434	1.03 × 1
Copper	Cu	1.73	0.0272		
Antimony	Sb	2.56	0.0213		
Bismuth	Bi	53.59	0.2576	2789	1.00 × 2
Sulfur (calculated)	S	17.80	0.5550	5550	1.00 × 4
Total		100.00			

The formula thus derived is:

$$Pb\ Bi_2\ S_4 \text{ or } PbS.Bi_2S_3.$$

The copper, iron, and antimony, while present in minor amount, merit note. Copper and iron while probably not entirely isomorphous with lead, can perhaps enter into solid solutions in limited amount, the copper in all probability being in the cupric state. It is possibly significant that copper and iron are molecularly roughly equivalent to the antimony and may be combined with it. Such an amount of copper and iron compounds might conceivably be present as submicroscopic inclusions in the galenobismutite.

BOTANY.—*A remarkable new species of* Ichthyothere.[1] S. F. BLAKE, Bureau of Plant Industry.

The genus *Ichthyothere* of the *Asteraceae* is of some economic importance among the native tribes of South America, since the bruised leaves and stems, placed in water, possess the property of stupefying fish and rendering them easy to capture. This property is shared with the closely allied genus *Clibadium* and with many other genera of various families, among which the *Fabaceae* and *Sapindaceae* are conspicuous.

Ichthyothere itself, as at present constituted, contains about a dozen species, all South American. All are low herbs or suffrutescent, with the few small whitish discoid heads in close clusters at the tips of the stems. In most species the heads are sessile, but in a few they are distinctly pedicellate.

While engaged in the preparation of a key to the species, I found in the National Herbarium a specimen from Colombia, doubtfully referred to this genus, and differing from all the species hitherto described in its loosely racemose-panicled heads and climbing habit. Through the courtesy of Dr. F. W. Pennell, the collector, I have had for study the more complete specimen of the same collection in the New York Botanical Garden. Detailed comparison with specimens of **Ichthyothere terminalis** (Spreng.) **Blake**,[2] the type of the genus, shows that its differences in habit and inflorescence are not associated with any important difference in technical characters, and, although so distinct in appearance, the plant is best considered a species of *Ichthyothere*. It may be recognized by figure 1 and by the following description.

Ichthyothere scandens Blake, sp. nov.

Shrubby vine; stems slender, branching, obscurely sordid-pilose with appressed hairs, glabrescent; leaves opposite; petioles slender, sparsely sordid-pubescent, 3 to 10 mm. long: blades ovate or lance ovate, 7 to 11 cm. long, 2 to 4.5 cm. wide, falcate-acuminate, at base acute or acuminate, finely serrulate, membranaceous, green on both sides, sparsely sordid-pubescent on the veins, glabrescent, tripli- or quintuplinerved; panicles axillary and terminal, very loose, dichotomous, obscurely puberulous, 16 cm. long or less; bracts minute, about 1.5 mm. long; heads loosely racemose along the branches, on pedicels about 4 mm. long, compressed, 4.5 mm. high, 5.5 mm. wide in fruit; outer phyllaries 5, subulate-triangular, coriaceous-herbaceous,

[1]Received May 31, 1921.

[2]*Rolandra terminalis* Spreng. Syst. Pl. 3: 673. 1826. *fide* BAKER in Mart. Fl. Bras. 6[3]: 154. 1884. *Ichthyothere cunabi* Mart. in Buchn. Rep. Pharm. 35: 195. 1830. For full synonymy see BAKER, *loc. cit.*

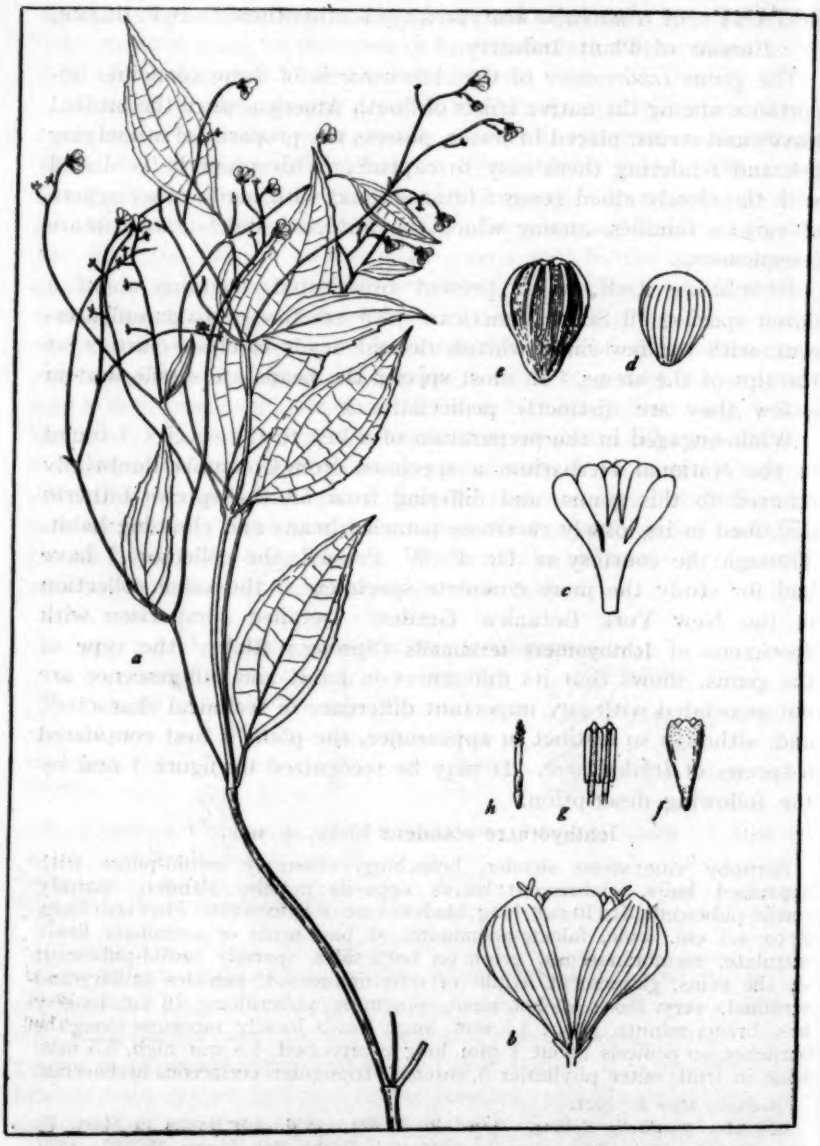

Fig. 1. *Ichthyothere scandens* **Blake.** ***a***, **branch, × 1/2;** ***b***, **head, × 5;** ***c***, **receptacle and pales, × 5;** ***d***, **phyllary subtending female flower, × 5;** ***e***, **achene, × 5;** ***f***, **disk flower, × 5;** ***g***, **stamens, × 5;** ***h***, **disk flower with corolla and stamens removed, showing ovary, gland surrounding base of style, and style, × 5.**

ciliate, 1 mm. long; inner phyllaries (subtending the female flowers) 2, obovoid, subherbaceous with thin margin, obtuse, glabrous, many-nerved, 5.5 mm. long; receptacle stipitate, bearing nine hermaphrodite sterile flowers; female flowers 2, their corollas tubular, annulate-pilose at apex, very short; corolla of the hermaphrodite flowers tubular-funnelform, greenish-white, 1.8 mm. long; achenes obovoid-turbinate, thick but somewhat obcompressed, truncate, about 8-ribbed, glabrous, 4.2 mm. long; pales of the disk suborbicular-cuneate to (inner) cuneate, glabrous, truncate or rounded, many-nerved with thinner apex, 2 to 3 mm. long.

Type in the U. S. National Herbarium, no. 1042822, collected in forest at Libano, Department of Tolima, Colombia, altitude 1100 to 1300 meters, December 26-29, 1917, by F. W. Pennell (no. 3430). Duplicate in the herbarium of the New York Botanical Garden.

Although in all its technical characters this species is clearly a member of the genus *Ichthyothere*, it is very distinct from all the previously known species in its scandent habit and its very loose inflorescence.

RADIOTELEGRAPHY.—*A chronographic recorder of radio time signals.*[1] E. A. ECKHARDT and J. C. KARCHER, Bureau of Standards. (Communicated by S. W. Stratton).

The problem of recording radio signals is one of amplifying the feeble energy in the radio signal to such a degree that in the amplified amount it is sufficient to operate a recording device. Whether the recording be done photographically or by means of some form of stylus, the electrical energy of the radio signal at some stage of the process gives rise to a mechanical motion. The aim of the experimenter is to make the chain of events between the receiving antenna and the mechanically moving element, as well as the apparatus embodying it, as simple and reliable as possible. If it is desired to use the recording apparatus in field service these considerations are especially important. Ruggedness then becomes an additional imperative requirement. The recording apparatus described in this paper was intended primarily for field use, since with it the U. S. Coast and Geodetic Survey wishes to record Annapolis time signals at any field station which it may desire to occupy within the borders of the United States.

So far as we know, success in recording radio signals at long range has heretofore been attained only by the use of amplifiers of many stages. Despite the great progress which has been made in the design and construction of such devices, a field party, which needs to give considerable attention to the weight of its equipment and which in general is not accompanied by a qualified radio engineer, will not

[1] Presented before the Philosophical Society of Washington, March 26, 1921. Received May 5, 1921.

contemplate their use with any degree of confidence. When a multiplicity of electron tubes is used the storage battery equipment presents a serious problem to the field party. Either the battery must be of large capacity or provision must be made for frequent charging. If, therefore, any radio receiver-recorder is to be available for service in the field, keeping the number of tubes down to a minimum is an important consideration.

The nucleus of our receiver-recorder is the regenerative circuit shown in figure 1. It consists of a capacity C_1 and inductance L_1 in the grid circuit of the electron tube, the inductance L_1 being coupled to the inductance L_2 in the plate circuit of the tube. In order that the circuit may be regenerative the coupling must be of such sign that a rise in plate current results in a rise in the grid potential. The potentiometer P serves to adjust the mean grid potential over a suitable potential range, both negative and positive.

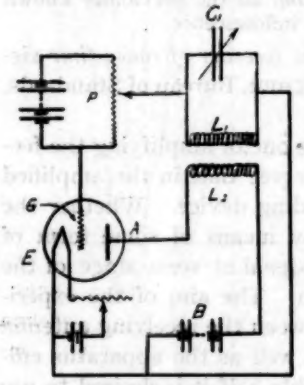

Fig. 1. Regenerative circuit.

Such a circuit is capable of acting as a generator of electrical oscillations. The frequency is determined in the main by the inductance capacity combination L_1 C_1.

If, by adjusting the potentiometer P, the grid potential is gradually made more and more negative, the oscillations are stopped. Upon gradually raising the potential it will be found that there is a critical grid potential at which the oscillations set in. This grid potential is characteristic for the circuit used.

Figure 2 shows a plate current-grid potential, characteristic of a typical receiver type electron tube. If the grid be at a mean potential corresponding to the point C, and an alternating e.m.f. be applied to it, the increase of plate current during the positive half of the cycle will be greater than the decrease during the negative half. This is due to the curvature of the characteristic. Thus the mean value of the plate current is increased by the periodic e.m.f. on the grid. If C, is the critical point on the characteristic at which the circuit becomes self-oscillatory, the amplitude of the periodic component of the grid potential builds up; likewise the amplitude of the periodic plate cur-

rent, and there results a rise in the mean plate current as shown by figure 2. By proper design, conditions may be so chosen that the rise in plate current occasioned by the initiation of oscillations in the regenerative circuit is many times the plate current flowing just be-

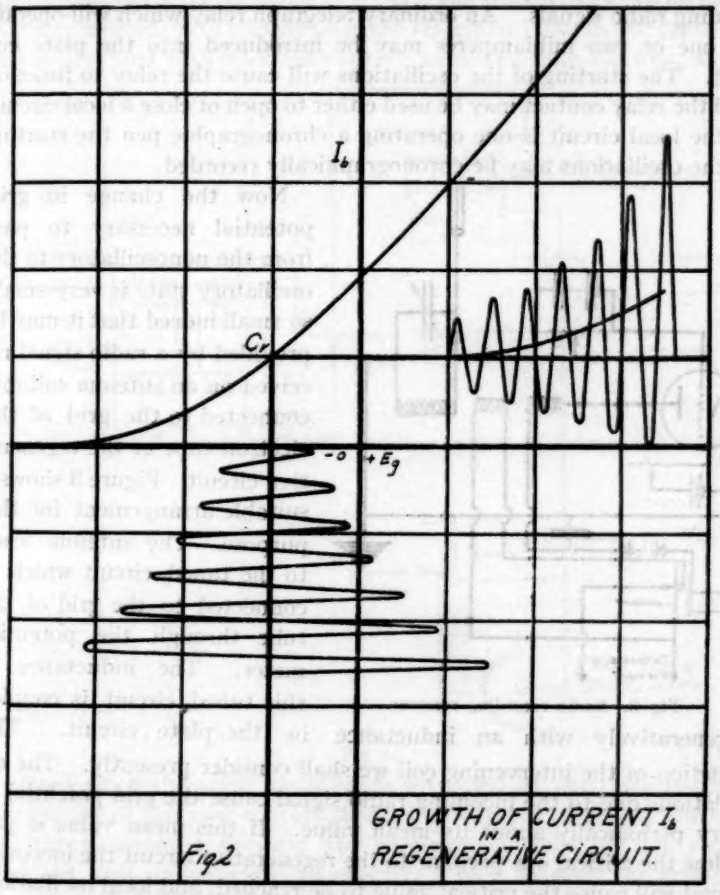

Fig. 2. Growth of current in a regenerative circuit.

fore the oscillations set in. Regenerative circuits have been operated by us in which the plate current shoots up from 2 or 3 milliamperes to 50 milliamperes when by raising the grid potential a small fraction of a volt the circuit is made to pass from the non-oscillatory to the oscillatory state. In our recorder the rise is from approximately $^1/_4$

milliampere in the non-oscillatory to 2 milliamperes in the oscillatory state.

The rise in mean plate current which accompanies the starting of the oscillations is an important feature from the point of view of recording radio signals. An ordinary telegraph relay which will operate on one or two milliamperes may be introduced into the plate circuit. The starting of the oscillations will cause the relay to function and the relay contact may be used either to open or close a local circuit. If the local circuit is one operating a chronographic pen the starting of the oscillations may be chronographically recorded.

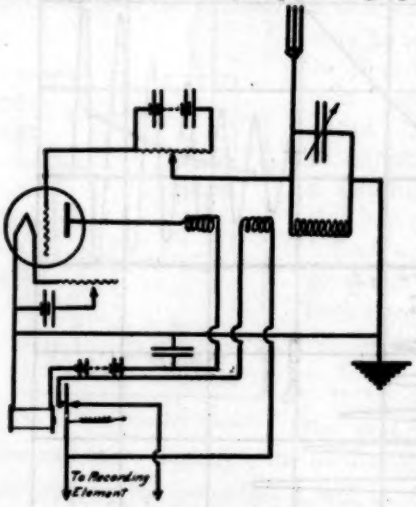

Fig. 3. Radio recording receiver.

Now the change in grid potential necessary to pass from the nonoscillatory to the oscillatory state is very small, so small indeed that it may be provided by a radio signal received on an antenna suitably connected to the grid of the electron tube of the regenerative circuit. Figure 3 shows a suitable arrangement for this purpose. The antenna leads to the tuned circuit which is connected to the grid of the tube through the potentiometer. The inductance of this tuned circuit is coupled regeneratively with an inductance in the plate circuit. The function of the intervening coil we shall consider presently. The oscillations due to the incoming radio signal cause the grid potential to vary periodically about its mean value. If this mean value is just below the critical one peculiar to the regenerative circuit the incoming signal will cause the critical value to be reached, and local oscillations will be initiated. Unfortunately, however, the local oscillations persist even after the mean grid potential has been restored to its original value below the critical one. To stop these oscillations by changing the grid potential it would have to be lowered considerably below the critical value. We are, therefore, thus far possessed of the means

for setting up local oscillations by the incoming signal, but the instrument does not automatically reset itself.

Means must be provided for killing the local oscillations as soon as the periodic potential variation of the grid has ceased, *i.e.*, when no signal is being received. For this purpose the telegraph relay in the plate circuit is provided with a second contact, insulated from the first, which

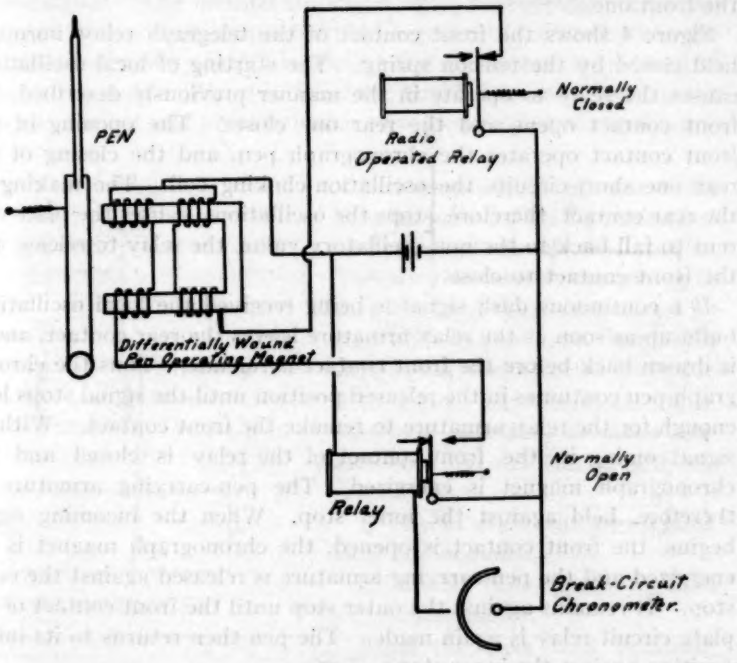

Fig. 4.

is closed when the relay armature is attracted by the relay magnet. The closing of this rear contact short-circuits a low resistance coil of a few turns mounted between the regenerating coils. When short-circuited, this coil provides an effective screen between the grid and plate inductances and regeneration is promptly stopped. The stopping of the local oscillations occasions a decrease in the plate current, the relay armature is released and the oscillation-stopping contact is opened. If the potential oscillations of the grid still persist as the armature is leaving the rear contact the local oscillations will immediately build up, the mean plate current will rise, and the relay armature will be

attracted to the relay magnet before it gets far enough away to make the outer, pen-controlling, contact. Thus, during a long dash signal the relay armature simply chatters against the rear contact, without at any time moving far enough to make the outer one. It is clear, therefore, that during the arrival of the signal the relay armature is chattering against the rear contact and between signals it rests against the front one.

Figure 4 shows the front contact of the telegraph relay normally held closed by the tension spring. The starting of local oscillations causes the relay to operate in the manner previously described, the front contact opens and the rear one closes. The opening of the front contact operates the chronograph pen, and the closing of the rear one short-circuits the oscillation-choking coil. The making of the rear contact, therefore, stops the oscillations, causes the plate current to fall back to the non-oscillatory value, the relay to release and the front contact to close.

If a continuous dash signal is being received the local oscillations build up as soon as the relay armature leaves the rear contact, and it is drawn back before the front contact is remade. Thus the chronograph pen continues in the released position until the signal stops long enough for the relay armature to remake the front contact. With no signal coming in, the front contact of the relay is closed and the chronograph magnet is energized. The pen-carrying armature is, therefore, held against the inner stop. When the incoming signal begins, the front contact is opened, the chronograph magnet is de-energized and the pen-carrying armature is released against the outer stop. It remains against the outer stop until the front contact of the plate circuit relay is again made. The pen then returns to its initial position against the inner stop.

In the recorder design now in use, a single stage of radio frequency amplification is provided so that the signal oscillations may be amplified before being applied to the grid of the tube in the regenerative circuit. This preliminary stage of amplification increases the overall sensitivity somewhat, but the regenerative circuit itself and the manner of its use account for all but a few per cent of the total sensitivity attained.

The preceding account describes a complete mechanism for recording radio signals. A similar recording system has recently been described by Captain L. B. Turner[2]. His methods of stopping the local oscil-

[2] The Electrician 83: 4. July 1919.

lations involve readjustments in the regenerative circuit when the oscillation-stopping contact is opened. If, for example, the plate inductance is short-circuited for the purpose of stopping the local oscillations, the removal of the short involves reëstablishment of a difference of potential at the terminals of this coil. This causes a surge which tends to restart the oscillations and results in the recording of a spurious signal. The method employed by us of stopping the oscillations involves no readjustments in the regenerative circuit when the oscillation-destroying contact is opened and the system is restored to the receptive state. We are, therefore, enabled to work very much nearer the critical grid potential with correspondingly enhanced sensitivity.

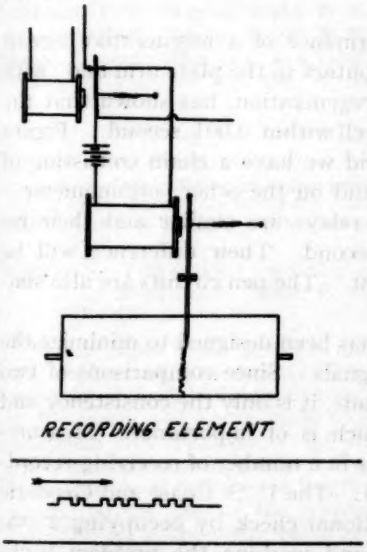

Fig. 5. Circuit recording element.

It is proposed to use the radio time recorder for the determination of the longitude of any station. This may be done by comparing in turn the local time ascertained by star observations and the radio time signal from a known longitude with a local chronometer. It is, therefore, necessary to make simultaneous records on a chronographic drum of

1. Local star transits against local chronometer.

2. Radio time signals against local chronometer.

From the data thus obtained, the longitude of the unknown station may be computed with reference to that of the radio time signal sending station.

It is obviously desirable to have the same lag in the recording apparatus for both signals. If, therefore, both can be recorded by means of the same mechanical system, *i.e.*, with the same pen, a serious cause of difference in lag has been eliminated. How this has been accomplished is illustrated in figure 5. The pen-operating magnet is differentially wound with two coils of approximately equal resistance and equal number of turns. The break-circuit chronometer operates a relay similar to that in the radio recieving-recording set. The clock-

controlled relay energizes one of the pen magnet coils during the brief period of the clock break. If the pen is in the released position during the clock break the pen magnet is momentarily magnetized and the pen is momentarily moved against the inner stop. If the pen is in the attracted position the clock break will serve to demagnetize the pen magnet momentarily and the pen will be released against the outer stop during the break. The pen will record the clock break, therefore, no matter what its status with reference to the radio signal.

When star transits are to be recorded simultaneously with a local chronometer, the pen magnet winding previously utilized for the recording of the radio signals may be included in a local signaling circuit. The tapping of the signal key then operates in a manner similar to the starting of a radio signal.

Oscillographic study of the performance of a regenerative circuit with a telegraph relay with double contact in the plate arm and with the screening coil for stopping the regeneration, has shown that the oscillations are started and stopped well within 0.001 second. Figure 5 shows clearly that on the one hand we have a chain consisting of antenna—relay—pen circuit—pen, and on the other, chronometer—relay—pen circuit—pen. The two relays are similar and their reaction times are less than 0.001 second. Their difference will be considerably smaller than this amount. The pen circuits are also similar, and finally the pen is identical.

It is seen clearly that the system has been designed to minimize the lag difference of the two kinds of signals. Since comparisons of two different kinds of signals are to be made, it is only the consistency and magnitude of the lag difference which is of importance. Measurements of this quantity are to be made in a number of receiving-recording sets prior to their use in the field. The U. S. Coast and Geodetic Survey proposes to obtain an additional check by occupying a station of precisely known longitude and working the problem backwards. Thus the lag will be subjected to independent measurement in the laboratory and in the field. It is confidently expected that by the use of this recorder a new order of precision will be attained in measurements of the kind in which this apparatus may be employed.

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ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. The abstracts should conform in length and general style to those appearing in this issue.

OPTICS.—*The contrast sensibility of the eye as a factor in the resolving power of the microscope.* FRED. E. WRIGHT. Journ. Opt. Soc. Amer. 2:101–107. 1919.

In this paper three factors of importance in high-power microscope work are emphasized, namely: (1) The use of a polarizing prism to eliminate that part of the field-light which does not contribute to the diffraction pattern in the image and hence tends to reduce the contrast and to decrease the sharpness and crispness of the image. This phenomenon arises because diffracted beams, which emerge from gratings whose interval is of the order of magnitude of half a wave length of light, are sensibly polarized in a plane normal to the lines of the grating. (2) a Diaphragm of the rectangular type, for use in the image plane of the eyepiece in order to cut out all light except that from the particular object under examination. The field should, however, cover at least 10°. (3) The importance of a field intensity of illumination approaching that of daylight and best adapted for the eye at any particular time. The simplest method for securing this is by means of a substage polarizer in conjunction with the polarizing prism; the polarizer can be rotated, and with it the intensity of illumination of the field varied. These factors are not important for ordinary observations, because the resolving power there required is not great; but in high-power, critical work they are significant and enable the observer to accomplish with comparative ease that which under other conditions is a matter of difficulty. F. E. W.

GEODESY.—*Latitude developments connected with geodesy and cartography, with tables, including a table for Lambert equal-area meridional projection.* OSCAR S. ADAMS. U. S. Coast and Geodetic Survey Spec. Publ. 67. (Serial 143). Pp. 132. 1921.

There are six different kinds of latitude that are found convenient in various cartographic and geodetic applications. In this publication the developments of the differences between each of these latitudes and the geodetic latitude are derived in Fourier series in terms of the geodetic latitude and afterwards expressed in terms of the particular latitude in question. In the case of two of the latitudes that are, from their definitions, somewhat complicated in their development, the series have been derived in several different ways. This procedure serves as a check upon the work and the methods in themselves are interesting applications of analysis to practical problems.

The coefficients of the series are expressed in terms of the eccentricity of the meridian ellipse; in this form they are applicable to any spheroid of reference. For the computation of tables, these coefficients were afterwards expressed in terms of the Clark spheroid of 1866, this being the spheriod of reference of the North American Geodetic Datum. In this form the coefficients are given in seconds of angle so that the result of a computation may be expressed in seconds of angular measure. The resulting coefficinets are given both as numbers for use in machine computation and as logarithms for work without calculating machine.

Tables are included for these latitudes computed for every half degree of latitude. In practical applications, these tables will be found of very great advantage since they give results that would require a great amount of computation if no table were available.

In addition to these latitude tables, there are given tables for transformation from latitude and longitude to arc distance and azimuth from a point on the equator. After these is given a table of the radial distance for a Lambert azimuthal equal-area projection upon a meridian plane, and finally there is included a table of the coordinates for this projection. O. S. A.

ZOOLOGY.—*Report on the Crinoids collected by the Barbados-Antigua Expedition from the University of Iowa in 1918.* AUSTIN H. CLARK. Univ. Iowa Studies. Studies in Natural History, 9 (First Series No. 45), 5, 1–28. March 15, 1921.

The crinoids collected by the Barbados-Antigua Expedition are minutely described; a history of the development of the study of the West Indian crinoids is given, and the faunal characteristics and relationships of the Caribbean region are discussed in detail; a key to the 30 genera of crinoids occurring in the Caribbean Sea is included; the author's 25 previous papers on the Lesser Antillean fauna (dealing with living and extinct birds, mammals, amphibians, fishes, insects and onychophores) are listed. A. H. C.

METALLURGY.—*The intercrystalline brittleness of lead.* HENRY S. RAWDON. Bur. Standards Sci. Paper 377. Pp. 19, figs. 11. 1920.

Sheet lead sometimes assumes a very brittle granular form during service, dne to corrosion. An explanation which has been offered by previous investigators for this change in properties is that it is due to an allotropic transformation, the product resulting from the change being analogous to the well-known "gray tin." The rate at which the intercrystalline brittleness is brought about is proportional to the amount of impurities and to the concen-

tration of acid in the solution in which the lead is placed. Practically all the impurities which are found in lead are lodged between the grains. The preferential attack by the corroding agent for these impurities and perhaps also for the "amorphous intercrystalline cement" accounts for the brittleness produced. Investigation showed that specimens of exceptionally pure lead (99.993 per cent), when immersed for 24 days in a neutral solution of lead acetate, became appreciably embrittled by the formation of minute intercrystalline fissures. No evidence of the existence of an allotropic form of lead similar to gray tin could be obtained. H. S. R.

CHEMICAL TECHNOLOGY.—*Inks—their composition, manufacture, and methods of testing.* Bur. Standards Circular **95**. Pp. 24. 1920.

The composition and manufacture are discussed only briefly, but the methods of testing which are in use at the Bureau of Standards are given in sufficient detail to enable any chemist to use them. After a brief introduction on the history of ink, there are discussions of writing and copying inks, ink tablets and powders, marking, cancelling, stamping, duplicating, and sympathetic inks. The methods used for the laboratory examination of all but the last of these kinds of ink are next taken up. The circular closes with a short bibliography.

RADIOTELEGRAPHY.—*Principles of radio transmission and reception with antenna and coil aerials.* J. H. DELLINGER. Bur. Standards Sci. Paper **354**. Pp. 63, figs. 17. 1919.

Coil aerials are coming to replace the large antennas in radio work. It is found that the coil aerial is particularly desirable for communication on short wave-lengths. A coil aerial is as powerful as an antenna only when its dimensions approach those of the antenna. For other reasons, however, a small coil aerial is in many cases as effective as a large antenna. An advantageous type of radio aerial is a condenser consisting of two large metal plates. This type of aerial has many of the advantages of the coil aerial. The fundamental principles of design of aerials are given in this paper. On the basis of this work the actual functioning of any type of radio aerial can be determined either from measurements made upon the aerials or from actual transmission experiments. J. H. D.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

848TH MEETING

The 848th meeting was held in the Assembly Hall of the Cosmos Club on March 12, 1921. It was called to order by President FARIS, with 43 persons present. The program was as follows:

T. S. SLIGH, JR: *Recent modifications in resistance thermometer construction.* (illustrated.)

A resumé of some of the more important phases of resistance thermometry led up to a brief discussion of present practice at the Bureau of Standards regarding the construction of resistance thermometers.

The most important points regarding present practice including recent modifications are: (1) The use of the potential terminal type of thermometer with Wheatstone bridge. (2) Thermometer leads made of 12 strands of No. 28 copper wire instead of the fine flexible strand previously used. (3)

Thermometer bridge terminals of thin copper. (4) Smaller and neater thermometer heads. (5) Sealing of the strain-free type of thermometer. (6) Elimination of the drying head on calorimeter thermometers. (7) A method of electrical annealing which seems to effectively relieve all winding strains in the thermometer coil. The subject matter of the paper is given in full in Bureau of Standards Scientific Paper No. 407.

The paper was discussed by DR. W. P. WHITE.

R. H. WILHELM and AMELIA K. BENSON: *A comparison of the International Hydrogen Scale with the standard scale of temperature defined by the platinum resistance thermometer.* (Illustrated; presented by Miss Benson.)

The International Scale of Temperature adopted by the International Committee on Weights and Measures in 1887 is the scale of the hydrogen thermometer set up by Chappuis at the International Bureau, the pressure of hydrogen at 0° C. being one meter of mercury. Chappuis calibrated four verre dur thermometers so as to define the mercury-in-glass scale, and compared these thermometers with his hydrogen thermometer to get the correction necessary to convert the verre dur scale to the hydrogen scale. Since the platinum resistance thermometer has proved to be a more reliable primary standard than the verre dur thermometer, it was decided to compare all the verre dur primary standards of the Bureau with platinum thermometers, and then place the verre dur thermometers in the vault.

The two scales have been compared by Griffiths in 1893, Waidner and Mallory in 1899, Harker and Chappuis in 1900, and the Bureau of Standards in 1917 and 1920. All the comparisons indicate that the hydrogen scale is lower than the standard platinum scale by perhaps 0.010 degree in the range 10° to 30° C.

The paper was discussed by Messrs. BURGESS, FENNER, HARPER, SOSMAN, MILLAR, SLIGH, and DICKINSON. The President announced that Miss Benson had the distinction of being the first woman who had ever addressed the Society.

C. O. FAIRCHILD: *New methods of sealing optical glass.* (Illustrated.)

A new process for joining optical glass has been developed which enables one to join glass parts with finished surfaces without distorting the surfaces except at an edge. It has been applied to the construction of colorimeter tubes, cells, etc., polarimeter tubes, incandescent lamps with optical glass windows, haemacytometers, and Nessler tubes, and the protection of surfaces for internal reflection.

The method is carried out by heating the glass parts while in approximate contact, in an electric furnace, to a temperature at or near the annealing range, and applying heat locally (usually at an edge) by means of a small oxy-gas flame. The progress of joining is viewed through a window in the furnace.

The process was developed through consideration of the low thermal conductivity of glass, and the rapid change in mobility near annealing temperatures. These properties make it possible to start fusion by local heating without propagating stress beyond a very restricted portion of the glass.

It has been found that two polished surfaces nearly in contact will join readily when junction is once started and it is possible to obtain excellent results without polishing the surfaces. A fine ground surface provides a good joint and the fusion is accomplished with almost complete disappearance of the ground part.

The method has proven to be the simplest and most satisfactory so far developed for the sealing of glass without distortion. It is, of course, particularly adapted to thin walled articles such as absorption cells and boxes.

The paper was discussed by Messrs. WHITE, FENNER, SOSMAN, CRITTENDEN, and others.

H. H. KIMBALL, *Recording Secretary.*

BIOLOGICAL SOCIETY

620TH MEETING

The 620th meeting was held in the lecture hall of the Cosmos Club on February 5, 1921, with President HOLLISTER in the chair and 50 persons present. On recommendation of the Council, Mr. GLENWOOD C. ROE and Mr. MAURICE K. BRADY were elected to membership. The deaths of Mr. W. J. BENNETTS on September 13, 1920, and Mr. W. W. WELSH on January 31, 1921 were announced, both having been members of the Society.

Informal Communications

Dr. H. M. SMITH exhibited a string of artificial pearls, and a bottle of finely comminuted fish scales in suspension. The industry of making artificial pearls was transferred to this country during the war, the Bureau of Fisheries assisting by suggesting fish whose scales were of desirable luster. Dr. Smith also exhibited the smallest and consequently the youngest eel ever captured. It was 2 cm. long, taken at 150 meters depth about 150 miles southeast of the Bermudas. This is the locality where fresh water eels of Europe and America resort to breed. The specimen was taken by Dr. SCHMITT in his recent expedition to study eels.

Dr. R. W. SHUFELDT stated that in his studies of birds and mammals fractured bones are sometimes found. An instance in *Oxymicterus rufus*, a large mouse from Brazil, was described, in which the greatly extended olecranon or elbow process of the forearm was broken, and a false joint had formed.

Regular Program

IVAR TIDESTROM: *Notes on the flora of the Iberian Peninsula.*

Mr. Tidestrom showed that Spain possessed 60 per cent of Europe's 10,000 species of plants, many of which are peculiar to Spain, and explained this fact, as well as the relation of Spain's flora to that of other countries, by her more continuous elevation above sea level in the later geological periods. The resemblance of Spain's topography to that of our own Southwest, and the similarity of climatic and botanical zones, was shown in detail. The paper was illustrated by maps, topographic sections, and landscapes.

R. S. BASSLER: *Paleontological work at the National Museum.*

The work of the National Museum is divided into three principal fields: the care of the collections, exhibition, and investigation. The space in the museum building is divided approximately into thirds among zoology, paleontology, and anthropology. In the exhibits of invertebrate and botanical paleontology, the plan is to have large exhibits, suitable for cursory observation, in the center of the halls; at one side, a series in geological sequence; and on the other side, further large exhibits showing details, restorations, and the like. In the hall of vertebrate paleontology another plan is necessary on account of the size and variety of the exhibits. The display here is deservedly popular on account of the admirable specimens, some of which are unique.

A. A. DOOLITTLE, *Recording Secretary.*

621ST MEETING

The 621st meeting of the Biological Society of Washington was held in the lecture hall of the Cosmos Club at 8 p. m., February 19, 1921. Vice-President A. S. HITCHCOCK presided, and forty seven persons were present. On recommendation of the Council, Mr. O. M. FREEMAN was elected to membership.

Informal Communications

Professor E. S. MORSE, former president of the Boston Society of Natural History, addressed the Society briefly. The Secretary read by title a paper by S. STILLMAN BERRY: *Notes on some Japanese Cephalopods; a review of Sasaki's "Albatross" report.*

Regular Program

C. E. MCCLUNG: *Chromosomes in relation to heredity.*

Modern biological work is characterized by greater exactness of methods and by the correlation of effort in different fields. These features are particularly marked in studies on heredity in which the existence of separate or unit characters has been determined and their exact numerical distribution observed. Correspondingly, careful and minute studies of the germ cells have revealed a mechanism which supplies a full explanation for the behavior of characters in heredity. Of primary importance is the observation that the character of an organism can be fully known only when the composition of its germ cells is understood. Thus, commonly, when two white animals are bred together, it is expected that their young will be white but cases are known where the result is a progeny of strongly colored coat. Such results are now understood and may be predicted in cases where the nature of the germ cells of the parents is known. The basis of all modern work in genetics was laid by an Austrian monk, Gregor Mendel, in the middle of the last century, but his results emained unknown for fifty years.

From a study of the mechanism of heredity, as revealed in the germ cells, it is found that the equivalence of the two parents is explained by their equal contribution of a substance, called chromatin, of most highly organized character. As one evidence of this organization the integration into a definite number of bodies, called chromosomes, is observed in every cell in each individual of a given species. Not only is the number exact but the size, form and behavior, so that it is possible to classify some animals by their chromosomes alone. In the structure and behavior of the chromosomes we find an explanation of the alternative inheritance of contrasting characters, of the chance distribution and recombination of characters, of their transmission in groups, and of breaks in these groups. An exact analysis of the structure of the chromosomes shows them to be made up of definite units whose number, arrangement and movements supply an explanation of the most detailed genetical studies. Finally it has been discovered that a particular chromosome is concerned with the determination of sex. (Author's abstract.)

The paper was illustrated by numerous lantern slides, and was discussed by Mr. T. L. CASEY.

SEWALL WRIGHT: *Heredity as a factor in the resistance of guinea-pigs to tuberculosis.*

The paper described some experiments which have been carried on by cooperation between the Bureau of Animal Industry and Dr. PAUL A. LEWIS of the Henry Phipps Institute of Philadelphia. The resistance to tuberculosis has been tested in about 800 guinea-pigs belonging to five closely inbred families, crosses between these families, and in a control stock which has never been inbred.

It was found that sex, age, rate of gain, and weight at inoculation made very little difference in the length of life after inoculation, determining in all less than 10 per cent of the observed variation. On the other hand, marked differences in resistance were found among the inbred families. Inbreeding itself was not a factor of great importance in increasing susceptibility although of the greatest importance in isolating different degrees of resistance. Two of the inbred families, with fifteen to twenty generations of exclusively brothersister matings back of them, were superior to the control stock, while three were inferior. The crosses between the families produced young which were in general at least equal to the better of the two parental families. Resistance is thus apparently dominant over susceptibility. There was equal transmission from sire and dam and to progeny of either sex. In certain crosses, the progeny were markedly superior to either parent strain, indicating that these strains were resistant for different reasons, each thus being able to supply what the other lacks. Among the crossbreds over 30 per cent of the variation in length of life was determined by the amount of blood of the best family, contrasting with less than 10 per cent determination by age, weight and rate of gain combined, and leaving something over 60 per cent determined by conditions at or following inoculation.

There was no relation between the rank of the inbred families in resistance to tuberculosis and their rank in other respects, such as average weight, fertility, and success in raising young. As in all of these cases, however, the importance of inbreeding in isolating hereditary differences was brought out by contrasting the marked differences among the inbred families and their crosses, with the lack of appreciable correlation between brothers within the random bred stock. (Author's abstract.)

The paper was illustrated by diagrams and curves, showing the tendencies discussed.

A. A. DOOLITTLE, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

THE PROPOSED CENTRAL ENGINEERING SOCIETY IN WASHINGTON.

The initial step toward the organization of a central engineering society in Washington was taken by the Washington Section of the American Society of Mechanical Engineers at its annual dinner on June 9. The plan, as outlined by Professor GEORGE A. WESCHLER, chairman, and A. R. CHEVNEY, secretary-treasurer of the Section, suggested that a larger organization be founded upon one of the existing societies as a nucleus, to be open to all engineering and technical men in the city, and to be governed by a representative body nominated by the local sections of the various national engineering societies. This plan is similar to that of the ACADEMY and its Affiliated Societies.

Messrs. A. G. CHRISTIE and W. F. BALLINGER reported on the experience of the Baltimore and Philadelphia Engineers' Clubs, respectively. Mr. L. W. WALLACE, executive secretary of the Federated American Engineering Societies, discussed the work of that organization. Dr. R. B. SOSMAN, secretary of the ACADEMY, spoke on the experience of the ACADEMY in forming such an organization.

Informal views of the plan were also presented by the following representatives of the Washington sections of the engineering societies: JOHN C.

HOYT, American Society of Civil Engineers; E. A. HOLBROOK, American Institute of Mining and Metallurgical Engineers; MILTON M. FLANDERS, American Institute of Electrical Engineers; HARRY D. APPLEBY, American Association of Engineers; H. C. DICKINSON, Society of Automotive Engineers; WILLIAM BLUM, American Chemical Society; S. TOUR, American Society for Steel Treating; and JOHN S. CONWAY, Washington Society of Engineers. Mr. WATSON DAVIS offered the aid of the scientific column of the *Washington Herald*, and there was informal discussion by W. H. BIXBY, A. M. HOLCOMBE, and others.

The meeting adopted a resolution endorsing the general idea of a central engineering organization and requesting the various societies interested to appoint delegates to meet at the call of the chairman of the Mechanical Engineers and draw up a detailed plan for submission to the societies.

Three societies may be considered available as a nucleus, namely, the Washington Society of Engineers, the local section of the American Association of Engineers, and the Council of the Federated American Engineering Societies. The last of the three, being a national federation, is less likely to be considered than the other two. The Washington Society of Engineers is the older organization of the remaining two, having been founded in 1905 and having at present about 500 members. The American Association of Engineers is a national organization, but is composed of individuals and not constituted by the combination of other organizations or their representatives.

Several of the speakers laid special stress upon the desirability of combining scientific, technical and engineering societies into a single federation, but no definite plan toward this end was presented.

Among the purposes of the proposed engineering organization would be the provision of a meeting place for the societies, the maintenance of a library for reference books and current periodicals, a central secretarial organization for the routine business of the societies, and the formation of committees to take an active part in civic affairs involving engineering and technical questions.

NOTES

The Washington Section of the American Society of Mechanical Engineers elected the following officers at the annual dinner on June 9: *Chairman*, L. A. FISCHER, of the Bureau of Standards; *Vice-Chairman*, O. P. HOOD, of the Bureau of Mines; *Secretary-Treasurer*, C. E. OAKES, of the Federal Power Commission.

The 14th National Conference on Weights and Measures was held at the Bureau of Standards on May 23–26. Among the subjects given special consideration at the meeting were: The sale of bread by weight, the detection of shortages, the weighing of coal, and the testing of pumps for measuring liquids.

The purchase of additional land near the Connecticut Avenue entrance to the National Zoological Park, provided for in the Sundry Civil Bill for 1921, has been completed. The addition to the Park is about 6 acres, making the total area about 175 acres.

The Radio Laboratory of the Bureau of Standards is cooperating with the Bureau of Markets of the Department of Agriculture in the establishment of a system of broadcasting market reports by radio. As it is likely that a

wide demand for radio equipment will develop, the Bureau has under way plans for the study of commercial apparatus and the preparation of specifications as to the behavior and usefulness of radio sets designed for general use.

The cases containing the exhibit of radium ores and radioactive minerals, prepared incidentally to the visit of Madame CURIE to Washington, have been removed from the Art Gallery of the National Museum and now form a permanent exhibit at the east end of the Mineral Hall of the Natural History Building.

Scales for the measurement of length are now being constructed directly from the fundamental wave lengths of light without the use of any intermediary standard such as the standard meter bars. For example, the Bureau of Standards has recently completed the rulings on a 6-inch standard scale for a manufacturing concern, using light waves from a neon tube as the length standard.

Dr. J. M. ALDRICH, associate curator of insects at the U. S. National Museum, left Washington in May for a two months' study of the insects, and particularly the Diptera, of central Alaska, along the line of the new Alaska Railroad between Seward and Fairbanks.

Vice-President CALVIN COOLIDGE has been elected chancellor of the Board of Regents of the Smithsonian Institution to succeed the late Chief Justice EDWARD D. WHITE.

Dr. F. G. COTTRELL, chairman of the Division of Chemistry and Chemical Technology, National Research Council, sailed for Europe in June to make a survey of current applications of oxygen and helium in European countries. He also expected to attend the meeting of the International Union of Pure and Applied Chemistry in Brussels on June 27.

Mr. S. T. DANA, assistant chief of the research branch of the U. S. Forest Service, has resigned to become land agent and forest commissioner of the State of Maine, with headquarters at Augusta.

Mr. ROBERT C. DUNCAN, physicist at the Bureau of Standards, has resigned to accept a position with the Bureau of Ordnance of the Navy Department.

Mr. F. C. FAIR, formerly Washington representative of the American Standardizing Bureaus, an organization having supervision of the manufacturing of pharmaceutical products for several associated companies, has become chief chemist of the Central Railway Signal Company at Hammond, Indiana.

Mr. CHARLES S. HAWES, in charge of the Bureau of Research and Statistics, War Trade Board Section, Department of State, died suddenly on Friday, April 22, 1921, in Chicago, Illinois. Mr. Hawes joined the War Trade Board in 1918 and remained with the new section when the old Board was dissolved. As head of its Bureau of Statistics he had been chiefly concerned of late with the importation of dyes, chemicals, and coal-tar products and had compiled a recently published report on dyes.

Mr. CARL L. HUBBS, curator of fishes in the Museum of Zoology, University of Michigan, has been studying the lampreys and lancelets of the National Museum collections, having been extended laboratory facilities for the purpose.

Dr. W. J. HUMPHREYS of the Weather Bureau has been elected Secretary of the American Geophysical Union, to succeed Dr. H. O. WOOD, resigned.

Mr. ENOCH KARRER has resigned from the Bureau of Standards to accept a position as physicist at the Nela Research Laboratory, Nela Park, Cleveland, Ohio.

Mr. SIDNEY D. KIRKPATRICK, chemist with the U. S. Tariff Commission, has resigned to join the editorial staff of *Chemical and Metallurgical Engineering*, in New York City.

Mr. ALBERT G. LOOMIS has resigned as assistant professor of chemistry at the University of Missouri to become physical chemist at the new cryogenic laboratory of the Bureau of Mines.

Dr. WILLIAM M. MANN, assistant entomologist in the U. S. Department of Agriculture, left Washington in June to accompany an expedition to the region of La Paz, Bolivia, under the direction of Dr. H. H. RUSBY, dean of the school of pharmacy at Columbia University. The main object of the expedition, which is financed by the H. K. Mulford Company, is the collection of herbs and plants likely to be of use in medicine, but general studies will also be made of the fauna and flora.

Dr. C. L. MARLATT, assistant chief of the Bureau of Entomology, U. S. Department of Agriculture, received the honorary degree of Doctor of Science from the Kansas State Agricultural College in June.

Dr. J. C. MERRIAM, president of the Carnegie Institution of Washington, received the honorary degree of Doctor of Science from Columbia University in June.

Dr. TAKEJIRO MURAKAMI, assistant professor in the iron and steel research institute of Tohoku Imperial University, Japan, visited Washington in June.

Mr. A. DE C. SOWERBY visited the scientific institutions of Washington in June, on his way to South China, where he will spend three years in an extensive biological survey, with particular attention to the higher vertebrates.

Dr. C. G. STORM has been transferred from the position of professor of chemical engineering at the Ordnance School of Application, Aberdeen Proving Grounds, Maryland, to the office of the Manufacturing Service of the Ordnance Department in Washington.

Dr. ALEXANDER WETMORE, of the Biological Survey, U. S. Department of Agriculture, has returned from a year's collecting trip in Argentina. He made a special study of the migratory shore birds.

Dr. H. O. WOOD, formerly assistant secretary of the National Research Council, has been appointed a research associate of the Carnegie Institution of Washington, and is in California engaged in a reconnaissance of the southern California seismological field, under the general supervision of an advisory committee in seismology appointed by the Institution.

Mr. HARPER F. ZOLLER, formerly chemist with the Dairy Division Research Laboratory, U. S. Department of Agriculture, is at present bacteriological chemist for the Nizer Laboratories Company, manufacturers of food products at Detroit, Michigan.